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# Design and Implementation of a Candy Color Sorter Device using Microcontroller-Based Color Sensor TCS3200

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**Abstract** – The purpose of this research is to design and implement a candy color sorter device using a microcontroller-based TCS3200 color sensor. This technology can be applied in the confectionery and fruit businesses for color-based sorting. The method used is an experimental approach that begins with a literature study, followed by hardware and software design, and device testing. The research results show that the candy sorter device was successfully designed and implemented. This device is capable of sorting candies based on red, green, and blue colors with optimal sensor detection levels. The novelty value of this research is the development of an automatic candy sorter device based on the TCS3200 color sensor, which can help reduce human workload and increase sorting process efficiency in the confectionery industry.

***Keywords****: Candy; Color; Microcontroller; Sorter; TCS3200 Sensor*

## I. Introduction

Currently, the development and use of technology in the industrial world have experienced very rapid development [1], and modern measurement techniques have also developed. This development is supported by the availability of hardware and software whose capabilities are increasing [2]. Currently, competition is so tight that product efficiency is considered the key to success. The product efficiency includes production speed, lowering material and labor costs, improving quality, and reducing rejects [3]. Color is the impression the eye gets from the light reflected by objects that are exposed to that light [4], every color can be measured or detected. When seen directly by our eyes, it is difficult to distinguish similar colors, for example between green and light green, etc. In physics, colors consist of primary colors. For light, the primary colors are red, green and blue, aka RGB (Red-Green-Blue). Color settings have different light waves, the Red, Green, and Blue (RGB) color space is a standard color space based on the acquisition of color frequencies by electronic sensors [5-6].

To be able to see colors in the light spectrum, the eye must be able to distinguish primary colors correctly, namely RGB (red, cyan). The development of science and technology has had a major impact on people's lives today, especially technology in the telecommunications sector. The rapid application of telecommunications technology has really helped people's lives in carrying out human activities and activities, especially those with special needs. Color temperature has a big influence, daytime color temperature is around 5000-6500 Kelvin, widely used as a standard in printing. The rapid development of electronic technology has had a very significant impact on efforts to lighten the human workload as

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execution subjects or sorting activities can be conducted manually relying on human subjectivity [7]. Therefore, researchers need a system that can carry out an automatic sorting process to measure or detect between light green and light green, and so on [8].

The design of candy color sorting tools generally has the effect of classifying candy based on color. If implemented, it can be applied to the confectionery business, its function can be applied in the development of candy products. Sorting generally aims to determine the classification of commodities based on similar qualities contained in the commodity itself [9]. In this research, the author created a tool using the TCS230 color sensor as a tool to detect the color of candy through the sorting process [10]. The TCS3200 sensor is used to obtain RGB values which are used to call servo movements [11]. At this stage, we have analyzed and interpreted the results of our previous data collection and processing. Our next step is to produce designs and prototypes for color-based candy sorting tools while paying close attention to product design criteria. We also analyze the selected criteria used in the design process. Finally, we test the design results of our candy sorter to determine the level of sensor detection performance.

## II. Materials

There are many components that can be used to make it easier for SMEs (Small and Medium Enterprises) to choose goods according to color, especially in this case candy colors. However, some tools are used for large-scale industries, and it is not possible for SMEs to invest in such equipment. The Candy Color Sorting Tool uses five main components, namely Arduino Uno, TCS3200 color sensor, DC Servo Motor, 16x2 LCD, Jumper Cables, 9 Volts Battery, and Breadboard.

Arduino Uno is used in the candy color sorting tool as an ATmega328 microcontroller which is an open-source single-board microcontroller. This device has an Atmel AVR processor, and the software has its own programming language [12]. For research projects, Arduino is not just a development part, but it is a combination of sophisticated hardware and programming language [13]. Previous research on fruit maturity sorting tools also used Arduino Uno as the main component of the tool control [14].

Color sensors are sensors used in microcontroller applications to detect an object or the color of the object being monitored. The color sensor used in this research is the TCS3200. The TCS3200 is a programmable IC which is useful for converting light color to frequency with an output in the form of a square signal [15]. The way the TCS3200 color sensor works is to convert color into frequency [16]. The TCS3200 color sensor can detect and measure a nearly unlimited range of visible colors [17].

For electric drives, the use of servo motors is also very important to support the candy sorting device. The servo motor is a driving motor to push objects into the box provided [18]. A Servo motor is a kind of DC voltage motor with adjustable rotation angle. A servo motor is a type of direct current (DC) motor that is specifically designed so that its rotation can be adjusted to a certain position in degrees [19].

The next main component is a 16×2 LCD (Liquid Crystal Display) which is used to provide visual information. This component is a module for displaying data that uses screen material to display data in the form of text or images [20]. To support the candy color sorting device, jumper cables are used as electronic component connectors. Jumper cables are components that connect the Arduino circuit to the circuit board. Jumper cables have 3 types of cables, namely male to female, female to female, and male to male [21].

## III. Research Method

The research method used in this research is an experimental approach which begins with a literature study as a reference in designing tools and writing. Next, hardware design and programming-based software design are conducted. After completing the design, the device will be manufactured and tested.

### *III.1. Device Design*

In electronics-based devices, the design of the device will generally involve hardware and software design [22]. In Fig. 1, there is a design for a candy color sorting tool using the TCS3200 color sensor which consists of several components such as an arduino uno, battery, LCD, color sensor, servo motor, and breadboard which are integrated with connecting cables.

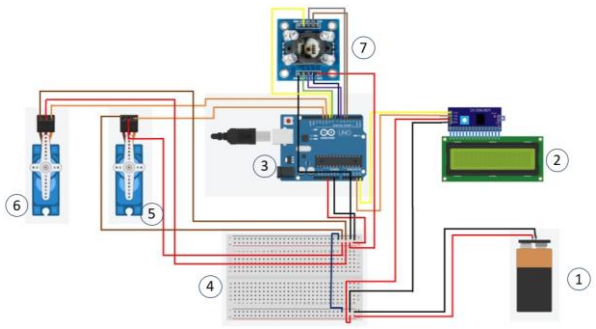

Fig 1. Design of Device Schematic Circuit

The detailed IoT schema components contained in Fig. 1. have a more detailed explanation of their specifications in Table 1.

Table 1. IOT Electronic system components

| No | Detail Part |
|---|---|
| 1. | Battery/Power Source |
| 2. | LCD 16x2 Plus I2C, |
| 3. | Arduino Uno |
| 4. | Project Breadboard |
| 5. | Mini Servo SG90 |
| 6. | Mini Servo SG90 no. 2 |
| 7. | Color Sensor TCS3200 |

In the IoT system of this candy color sorting device, there are several main components, including a battery power source, a 16x2 LCD with I2C for displaying information, an Arduino Uno as the controlling microcontroller, a breadboard for assembling components, two mini SG90 servos tasked with moving the candy and sorting it into containers according to color, as well as a TCS3200 color sensor that detects and converts the candy color into RGB values for the sorting process.

Next, a working drawing was made to make it easier for researchers to make hardware devices. The working drawing created place the components according to their working positions, as shown in Fig. 2. The detailed design components found in Fig. 2. have the same explanations as their specifications in Table 1.

Figure 2 explains the design of the candy color sorting device using the TCS3200 color sensor, which functions to detect and convert the candy color into frequency, providing RGB values. The first mini SG90 servo is used to move the candy to the color sensor path. After the candy color is detected, the second mini SG90 servo will move the candy to the container corresponding to the detected color. All components are assembled on the frame, which serves as the main support, forming this candy color sorting device.

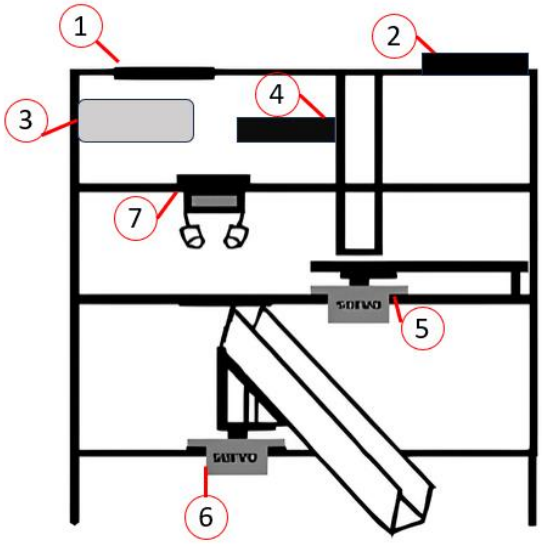

Fig 2. 2D Device Design Drawing

### *III.2. Workflow Chart*

On the Device for Sorting Candy Colors Using the TCS3200 Color Sensor, the flowchart flow begins with start and then receives the programmed data command as shown in Fig. 2. Servo motor 1 will always carry candy as an object, then continue with the color sorting stage by the TCS3200 color sensor, after that the candy is sorted and then servo 2 will drop it into the container according to the color of the candy.

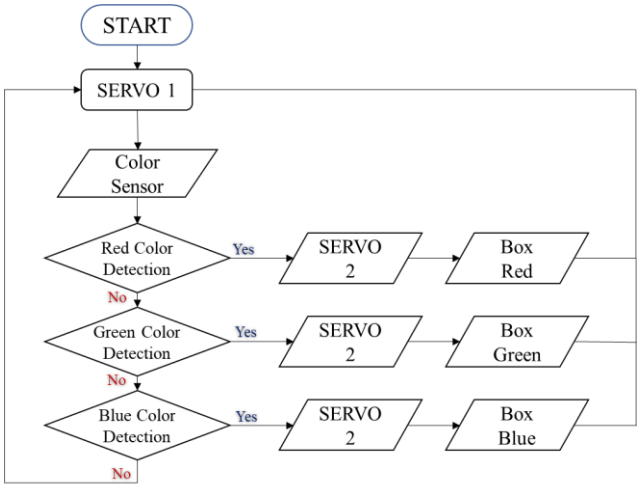


Fig 3. Device Workflow

### *III.3. TCS3200 Sensor Calibration Program*

To set the TCS3200 can be used as a color sensor for sorting candy, researchers must first calibrate the sensor with the following program code:

```
// CANDY COLOR SORTING DEVIDE USES TCS3200
COLOR SENSOR
#define S0 4
#define S1 5
#define S2 6
#define S3 7
#define sensorOut 8
#define LED 9

int redFrequency = 0;
int greenFrequency = 0;
int blueFrequency = 0;
void setup() {
  // Setting the outputs
  pinMode(S0, OUTPUT);
  pinMode(S1, OUTPUT);
  pinMode(S2, OUTPUT);
  pinMode(S3, OUTPUT);
  pinMode(sensorOut, INPUT);

  digitalWrite(S0,HIGH);
  digitalWrite(S1,LOW);
  digitalWrite(LED, HIGH);

  Serial.begin(9600);
}
void loop() {
  digitalWrite(S2,LOW);
  digitalWrite(S3,LOW);

  redFrequency = pulseIn(sensorOut, LOW);

  Serial.print("R = ");
  Serial.print(redFrequency);
  delay(100);

  digitalWrite(S2,HIGH);
  digitalWrite(S3,HIGH);

  greenFrequency = pulseIn(sensorOut,
LOW);

  Serial.print(" G = ");
  Serial.print(greenFrequency);
  delay(100);

  digitalWrite(S2,LOW);
  digitalWrite(S3,HIGH);

  blueFrequency = pulseIn(sensorOut, LOW);
    Serial.print(" B = ");
  Serial.println(blueFrequency);
  delay(100);
}
```

### *III.4. Device Operational Program*

After calibrating, the next program that must be set is the code to run the program. These codes are used to run the tool's operational system. Details of the program code used are as follows:

```
// CANDY COLOR SORTING DEVIDE USES TCS3200
COLOR SENSOR
#include <Wire.h>
#include <Servo.h>
//I2C Library
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);

#define S0 4
#define S1 5
#define S2 6
#define S3 7
#define sensorOut 8
#define LED 9

Servo sCandy;
Servo sPosition;

int posRed = 0;
int posGreen = 25;
int posBlue = 50;
int posCandy1 = 0;
int posCandy2 = 40;
int posCandy3 = 90;

int redFrequency = 0;
int greenFrequency = 0;
int blueFrequency = 0;

int redColor = 0;
int greenColor = 0;
int blueColor = 0;

void setup()
{
 //initial LCD
```

```
 sCandy.attach(10);
 sPosition.attach(11);
 sPosition.write(0);
 sCandy.write(posCandy1);
 lcd.begin();
 lcd.backlight();
 lcd.setCursor(1,0);
 lcd.print(" Color Sort ");
 lcd.setCursor(0,1);
 lcd.print("     Candy");
 delay(1500);
 lcd.clear();
 lcd.setCursor(1,0);
 lcd.print("Candy Color Sorter");
 lcd.setCursor(0,1);
 lcd.print("   20518241016");
 delay(1500);
 lcd.clear();
 lcd.setCursor(0,1);
 lcd.print("   Color   ");
  Serial.begin(9600);
  // Setting output
  pinMode(S0, OUTPUT);
  pinMode(S1, OUTPUT);
  pinMode(S2, OUTPUT);
  pinMode(S3, OUTPUT);

  // Setting sensorout
  pinMode(sensorOut, INPUT);

  // Setting Frequency
  digitalWrite(S0,HIGH);
  digitalWrite(S1,LOW);
  digitalWrite(LED,HIGH);

  // Begins serial LCD
  Serial.begin(9600);
}

void loop() {
  // Setting RED Color
  sCandy.write(posCandy1);
  delay(3000);
  sCandy.write(posCandy3);
  delay(1000);
  sCandy.write(posCandy2);
  delay(5000);
  digitalWrite(S2,LOW);
  digitalWrite(S3,LOW);
  lcd.setCursor(2,0);
  lcd.print("CANDY");
  redFrequency = pulseIn(sensorOut, LOW);
  redColor = map(redFrequency, 4700,
11000, 255,0);

  Serial.print("R = ");
  Serial.print(redColor);

  // Setting GREEN Color
  digitalWrite(S2,HIGH);
  digitalWrite(S3,HIGH);

  greenFrequency = pulseIn(sensorOut,
LOW);
  greenColor = map(greenFrequency, 5180,
10000, 255, 0);
  Serial.print(" G = ");
  Serial.print(greenColor);

  // Setting BLUE Color
  digitalWrite(S2,LOW);
  digitalWrite(S3,HIGH);

  blueFrequency = pulseIn(sensorOut, LOW);
  blueColor = map(blueFrequency, 5430,
12000, 255, 0);

  Serial.print(" B = ");
  Serial.print(blueColor);

  if(redColor > greenColor && redColor >
blueColor){
      Serial.println("  Warna Red");
    lcd.setCursor(8, 1);
   lcd.print(" Red  ");
   delay(100);
   sPosition.write(posRed);
  }
  if(greenColor > redColor && greenColor >
blueColor){
    Serial.println("Green");
     lcd.setCursor(8, 1);
   lcd.print("Green");
   delay(100);
   sPosition.write(posGreen);
  }
  if(blueColor > redColor && blueColor >
greenColor){
```

```
    Serial.println("Blue");
    lcd.setCursor(8, 1);
  lcd.print(" Blue  ");
  delay(100);
  sPosition.write(posBlue);
}
```

## IV. Experimental Result and Discussion

### *IV.1. Device Work Concept*

This device uses two DC servo motors as seen in Fig 4, the first DC servo is used for filling candy and the second DC servo is used for sorting candy. Next, after the candy is filled into the holding container, the color sensor will detect the candy. The sensor will take readings regarding the color of the candies one by one and after the color is detected then the second DC Servo will shift the candies and they will fall into the container provided according to their color.

The components of the IoT scheme shown in Fig. 4. is an implementation of the schematic design found in Fig. The code on the component also has the same explanation as its specifications in Table 1.

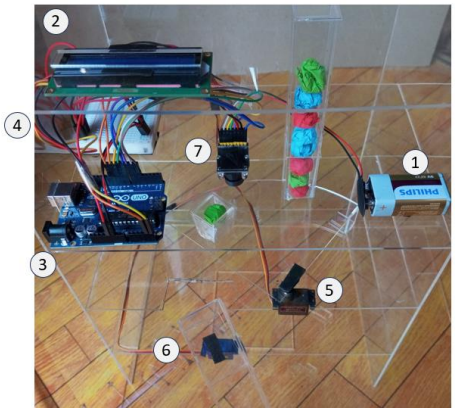


Fig 4. Device Prototype

In the circuit in this device, two sources are used, namely from Arduino and a 9V battery. The implementation concept begins by connecting the Arduino print cable to the PC and installing the battery in the connector. The next step is to calibrate the color sensor first due to each room has a different light intensity. After completing the calibration, the device operational program must be input, and the device can be used.

Data input via the TCS 3200 color sensor module will input the color frequency so that the TCS 3200 color sensor module will detect color, and also provide input voltage to run the program. The TCS 3200 color sensor module will be able to receive color input, namely Red, Green and Blue. When the color sensor module receives a frequency, the servo motor will sort the colors automatically according to the program that has been determined.

### *IV.2. Device Testing*

As a result of the device experiments that have been conducted, the work of the Arduino Uno will provide an output voltage to the servo motor to move the work object (candy) and will run the program automatically when servo 1 moves the candy from the sensor position. Then the sensor will read the color of the candy and when the color of the candy is detected, servo 2 will move to direct it to the specified container automatically. These programs will continue to repeat until the candy has run out by implementing the system as shown in Table I.

Table 2. System of servo motor in the device

| No | Components | Function |
|---|---|---|
| 1 | Servo 1 (Upper) | Move towards the color sensor |
| 2 | Servo 2 (Down) | Moves when the color sensor detects an object |

In the initial condition when the tool is started to be used, servo motor 1 rotates and servo motor 2 does not rotate. Next, the color sensor lights up but does not detect the color frequency. After sensor 1 successfully pushes the candy, the color sensor will light up and servo motor 2 will direct the candy to the container according to its color. The distribution of candy colors can be seen in Table II. During the two-hour experiment, the color sensor was able to sort colors optimally and the servo motor was able to work according to the set concept.

Table 3. Device test result

| No | Candy Colors | RGB value | Servo Motor | Sensor | Action |
|---|---|---|---|---|---|
| 1 | **Red** | R = 372<br>G = 255<br>B = 361 | Active | Detect | Go to the red container |
| 2 | **Green** | R = 295<br>G = 396<br>B = 348 | Active | Detect | Go to the green container |
| 3 | **Blue** | R = 384<br>G = 470<br>B = 498 | Active | Detect | Go to the blue container |

In the experiment that the researchers conducted on a tool for sorting candy based on color as shown in Fig 5, there were input, output and overall results from the tool that had been tested.

Color-based candy sorter testing is conducted in ideal conditions and noise conditions. The test will determine the RGB frequency on the serial monitor so that it can recognize the colors red, green, yellow, and blue in candy so that the DC servo motor below will arrange the candy into predetermined color containers.

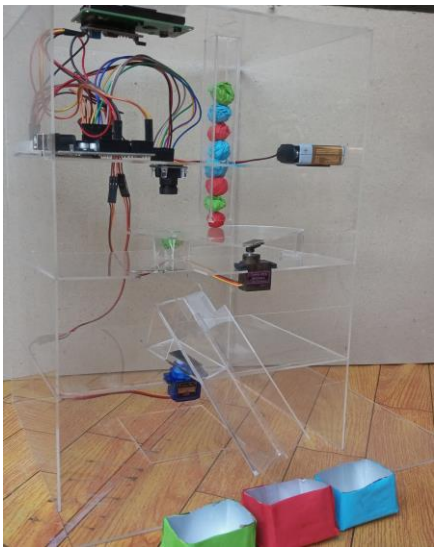

Fig 5. Device Testing

## V. Conclusion

This research successfully designed and implemented a candy color sorting device using a microcontroller-based TCS3200 color sensor. The test determined the RGB frequency on the serial monitor so that it could recognize the colors red, green, and blue in the candies, allowing the DC servo motor to sort the candies into containers with specified colors and with good sensor detection levels. The novelty of the research lies in the development of an automatic candy sorting device based on the TCS3200 sensor, which can help reduce the human workload in the sorting process in the confectionery industry and increase process efficiency. Thus, the research objective to design a candy sorting device based on color has been well achieved.

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